UNCLASSIFIED

Defense Technical Information Center Compilation Part Notice

ADP010632

TITLE: Formative Evaluations of the Vesub Technology Demonstration System

DISTRIBUTION: Approved for public release, distribution unlimited

This paper is part of the following report:

TITLE: The Capability of Virtual Reality to Meet Military Requirements [la Capacite de la rea1ite virtuelle a repondre aux besoins militaires]

To order the complete compilation report, use: ADA388966

The component part is provided here to allow users access to individually authored sections of proceedings, annals, symposia, ect. However, the component should be considered within the context of the overall compilation report and not as a stand-alone technical report.

The following component part numbers comprise the compilation report:
ADP010609 thru ADP010633

UNCLASSIFIED

FORMATIVE EVALUATIONS OF THE VESUB TECHNOLOGY DEMONSTRATION SYSTEM

Robert T. Hays, Ph.D.
Naval Air Warfare Center Training Systems Division
Code 4962
12350 Research Parkway
Orlando, FL 32826, USA

BACKGROUND

Decreasing military budgets, reduced training infrastructure, and increasing complexity of weapon systems and missions mandate the exploitation of innovative advanced training technologies. In recent years, training developers have recognized the potential of virtual reality (VR), often called virtual environments (VE), as a flexible and effective training medium. A prime candidate area for examining the effectiveness and usability of VR systems is the training of the submarine surfaced ship handling task. Although land-based simulator facilities currently exist for training Submarine Piloting and Navigation teams, these systems do not provide detailed harbor and channel ship handling training for the Officer of the Deck (OOD). OOD training is primarily obtained from on-the-job experience, which is adversely impacted by the operational constraints of the Submarine Force, and the limited surfaced steaming time of submarines. Training that will expose junior officers to a variety of geographical and environmental conditions is very limited since most Commanding Officers place their most experienced OODs on watch during these challenging evolutions. Therefore, an alternative, high-fidelity, simulation-based training capability is needed. A VR-based simulation may provide this necessary capability if it is both effective and user-friendly.

OBJECTIVE OF VESUB

The goal of the Virtual Environment for Submarine OOD Ship Handling (VESUB) project is threefold: (1) to develop, demonstrate, and evaluate the training potential of a stand-alone virtual reality-based system for OOD training; (2) to integrate this system with existing Submarine Piloting and Navigation (SPAN) training simulators; and (3) to determine the viability of VR technology as a training tool.

DESCRIPTION OF VESUB

The VESUB technology demonstration system uses a high-resolution head mounted display (HMD) to provide the trainee with a simulated 360 degree representation of the visual environment containing many of the required cues associated with harbor and channel navigation as well as accurate cultural features and varying environmental conditions. Voice recognition and synthesis are used to provide communications training. Visual scene rendering, computation of harbor currents, wind effects, hydrodynamics of own ship and traffic ships require state-of-the-art hardware and software, including:

- Silicon Graphics Onyx Image Generation Computer (Infinite Reality configuration)
- n-Vision Datavisor HiRes HMD (1280 x 1024 pixels resolution)
- Polhemus 3 space Fastrack Head Tracker (Magnetic)
- ModelGen2 from Multigen, Inc. (creation of models and terrain)
- Vega Marine from Paradigm Simulation, Inc. (marine visual effects)
- HARK, Speaker-Independent Voice Recognition software

Additional details on VESUB hardware and software may be found in Hays, Seamon, and Bradley (1997).

VESUB DEVELOPMENT PHASES

The VESUB project was organized in three phases: 1) requirements determination; 2) formative evaluations; and 3) training effectiveness evaluations.

Paper presented at the RTO HFM Workshop on "The Capability of Virtual Reality to Meet Military Requirements", held in Orlando, USA, 5-9 December 1997, and published in RTO MP-54.

Requirements Determination Phase

The requirements determination phase was the first year of the project. During this phase, a simplified feasibility demonstration system, developed under the NAWCTSD exploratory research Virtual Environment Training Technology project, was used to elicit VESUB system requirements from Navy subject matter experts (SMEs). The initial functional requirements were documented in a NAWCTSD special report (Tenney, Briscoe, Pew, Bradley, Seamon, & Hays, 1996) and used to direct the contractor during the development of the VESUB technology demonstration system.

Additional VESUB functional requirements and training objectives were developed around the organizing concept "Seaman's Eye," defined by the VESUB research team as follows:

> *Seaman's Eye: The total situation awareness of the ship handling environment and the ability to safely maneuver the vessel in all conditions.*

The perceptual and cognitive components of "Seaman's Eye" were identified and used to help determine hardware, software, and instructional requirements. Details on how the perceptual components were used to help select VESUB hardware may be found in Hays, Castillo, Bradley, and Seaman (1997).

Formative Evaluation Phase

Formative evaluations serve as initial tests of the configuration and instructional methods included in the training system. These evaluations help the training developer to avoid or correct costly mistakes before they are finalized in the configuration of the training system. The software development and hardware integration for VESUB was accomplished under contract by Nichols/Advanced Marine. The contractor developed the VESUB system at their offices near Washington, DC. The VESUB formative evaluations were conducted on a duplicate VESUB system in the laboratory at NAWCTSD during the second and third years of the project. Each time the development contractor produced an improved iteration of the software, it was installed in the VESUB laboratory and evaluated against the functional requirements. Over ten iterations of the system have been produced and evaluated.

Data for the formative evaluations were collected from a wide range of SMEs. These included: full time retired Navy submariners; active duty Navy submarine SMEs from the fleet and training facilities; and Navy reservists. Recommendation for system improvements were provided to the software developer for improvement of the next system iteration. A brief summary of the results of the formative evaluations are presented below.

Training Effectiveness Evaluations

The training effectiveness evaluation (TEE) phase will include TEEs of the VESUB technology demonstration system. The first TEE will be conducted at the Submarine Training Facility in Norfolk, Virginia during January 1998 and the second will be conducted at the Naval Submarine School in Groton, Connecticut during March 1998. The TEEs will use actual Navy trainees with various levels of experience (novice to expert) to determine the effectiveness of the VESUB system and also to help determine how the technology can be integrated into Navy training. During the Norfolk TEE, VESUB will be connected to the SPAN trainer to determine if the modern VESUB hardware and software can communicate with the older SPAN system. If feasible, the future operational VESUB systems will be interfaced to SPAN trainers to provide interactive OOD training with other members of the Navigation Team. The results of the TEEs and other lessons learned during the VESUB project will be documented for use in the acquisition of the operational VESUB systems.

Acquisition of Operational VESUB Systems

Current plans call for the acquisition of operational VESUB systems, beginning in 1999. The systems will be installed at the Navy's five major submarine training facilities. The VESUB technology demonstrations system will serve as a functional baseline, which will have to be matched or improved. The operational systems will include the functionality of the demonstration system and improve on this functionality, based on the results of the TEEs.

RESULTS OF THE FORMATIVE EVALUATIONS

VESUB formative evaluations focused on both the functionality of the trainee interface (e.g., the fidelity of objects in the visual scene or the responsiveness of the voice recognition system), and the usability of the Instructor/Operator Station (IOS). The results of the IOS usability analysis are presented in Hays, Seamon, and Bradley (1997). This report documents twenty-two areas where the design of the operational VESUB system IOS can be improved.
Hundreds of SME recommendations for improvement of the trainee interface were collected during the formative evaluations. These recommendations ranged from very general (e.g., improvements in the representation of equipment on the submarine bridge) to very specific (e.g., the logic supporting the "angle on the bow" display on the IOS). The recommendations were provided to the system developer and prioritized for inclusion in subsequent software iterations. Only a limited number of the recommendations could be included in the demonstration system due to budget, schedule, and technology constraints. For example, in March and April of 1997, seventy-three major system requirements were reduced to twelve. Two examples of requirements that were not implemented are: time varying fog (e.g., fog bank "rolling" in rather than instant reduction of visibility) and secondary propulsion motors (used when the rudder or main engine fails and for docking maneuvers). Two examples of requirements that were included in the system are: environment sounds (e.g., ship whistles, bells on buoys, wind, and rain); and latitude/longitude organization of the databases (rather than an x-y coordinate system as in previous ship handling trainers). An example of a partially developed function, which will require improvement in the operational system, is collision detection. Finally, several unanticipated requirements were recognized only after initial versions of the software were evaluated. An example of these unanticipated requirements is large area database management (required because of the need to display both close and distant objects in the visual field). Details on the trade-offs made during system development will be documented in a final "lessons learned" report.

CONCLUSIONS

The development of a complex training system, like VESUB, requires the dedicated efforts of a team of experts including: computer scientists, visual engineers, task SMEs, and instructional psychologists. It is essential that a substantial period of formative evaluations be included in the development of any such training system. It is not possible to anticipate even a fraction of the problems that will be encountered during system development. Formative evaluations provide the opportunity to correct problems before they are fully implemented in the system and become too costly to correct. As training systems, VE-based or otherwise, become more advanced, they also become more complex. This complexity brings unanticipated difficulties, which will require innovative and timely solutions. Formative evaluations provide the opportunity for system developers to apply these solutions at a stage where they can have a positive benefit to training system effectiveness.

REFERENCES

Hays, R. T., Castillo, E., Bradley, S. K., & Seamon, A. G. (1997). A virtual environment for submarine ship handling: Perceptual and hardware trade-offs. In M. J. Chinni (Ed.), Proceedings of the 1997 Simulation MultiConference: Military, Government, and Aerospace Simulation (April 6-10, 1997). Simulation Series 29(4), 217-222. San Diego, CA: The Society for Computer Simulation International.

Hays, R. T., Seamon, A. G., & Bradley, S. K. (1997). User-oriented design analysis of the VESUB technology demonstration system (NAWCTSD TR 97-013). Orlando, FL: Naval Air Warfare Center Training Systems Division.

Tenney, Y. J., Briscoe, H., Pew, R. W., Bradley, S. K., Seamon, A. G., & Hays, R. T. (1996). Virtual environment submarine officer of the deck simulation and training: Preliminary requirements recommendation (NAWCTSD SR 96-002). Orlando, FL: Naval Air Warfare Center Training Systems Division.